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The Effect of Three Block-Pedal Angles on Kinematics of the First Contact during a Sprint-Start Performance

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Abstract

Athletes have considerable freedom in altering the block spacing and block obliquity to personalize it to their convenience, they have relied on experience to develop the bock configuration of their preference. There is little research exploring this area and is therefore worthy of scrutiny. So the objective was to test if the alterations in the block-pedal angles continue their effect until the First step in a sprint start performance.2-D videography method was used to study the sprint start performance of five highly trained athletes. One-way ANOVA was used to determine the deference in lower-limb kinematics at the first contact at various block angles. The results showed no statistical difference between the kinematics of the lower limbs at the initial contact at various block-obliquities. The study concluded that there was no measurable difference in the kinematics at initial contact of highly trained athletes.

Keywords: Block-pedal angle, lower limb kinematics, Sprint-start performance

INTRODUCTION

Sprint is a marvelous event. It remains one of the most celebrated track and field events with viewership in billions across the globe (IAAF,2008). Athletes set in their blocks anticipating the gunshot and approximately 10 seconds later someone has already won the event. However, to optimize the performance in these ten seconds of time athletes practice for years and any fair intervention that gives advantage over the opponent is always appreciated.

One of the most crucial phases in the total sprint is the sprint-start performance as it is strongly correlated with the 100m performance (Bezodis et al., 2015; Tellez & Doolittle, 1984). A sprint-start performance is the initial part of the sprint including the block-clearance as well as the few subsequent steps. The clearance time from the start-block accounts for 5% of the total time taken in a 100m sprint (Hussain et al.,2019). This is a substantial amount of time that a runner capitalizes to break the inertia of his body and go into the acceleration phase of the sprint. The subsequent phases after the block-clearance are also major contributing factors to the sprint start performance and have also gained much attention (Mero & Komi 1990; Coh et al., 2009; Bezodis et al.,2014; Bezodis et al.,2015 ; Ciacci et a., 2017). However, very little is known about the kinematics at the first contact of elite athletes.

The block is a tool that is essential in national and international sprint events as it gives the

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athlete a dynamic and a powerful start. Athletes have a considerable freedom in choosing the spacing and altering the inclination of the block which can be personalized to their convenience to obtain a greatest amount of joint power (Mero et al., 2006). Theoretically, the steeper the block-pedal the more horizontal push an athlete can generate which is considered as an advantage (Bezodis et al.,2015). This is supported by one study (Ciacci et al.,2017). However, more studies state the contrary, with studies reporting increased horizontal velocity (Guissard et al., 1992), block-exit velocity (Mero et al., 2006), and angular velocity at ankle joint (Han et al., 2015) at lower block angles. Although it's not disputed that the block-pedal inclination has a profound effect during the block clearance, however the knowledge about the kinematics at first contact and weather the variation in block-angle has any implication on the kinematics at the first contact remains poorly understood.

MATERIAL AND METHODS

Participants: A total number of five national level athletes/sprinters (gold medallists) with high success in national level events participated in this study. The athletes were highly trained (7.6±2.07, years) and highly skilled (10.704±0.255 seconds; 100m personal best) and had no record of any recent injuries. The age(mean±SD) of the participants was 26.8±1.92 years, height was 1.71.2±5.17 cm, body weight was 65.4±6.1 kg, leg length was 83.4±7.02 cm. Filming Protocol: Motion analysis method was used to record the data on the athletes in motion. The camera (Sony Camcorder HDRCX 405) was set-up at 60 frames/sec with 1.0 zoom to record the data in HD (1920x1080 pixels). The camera was placed perpendicular to the plane of motion which exposed the right side view of the athlete such that the camera would capture the athlete in the blocks as well as the three subsequent steps. The camera was fixed on a tripod at a height of 0.8m and 7m away from the athlete's block.

Testing Protocol: The athletes were briefed about the experiment one day before the data was recorded. The athletes arrived at the tartan track in the morning 7.30 am where the equipment was already set-up by the researcher and his assistant. The participated went for a personalized warm-up which consisted of jogging, followed by stretching exercises. All the five athletes wore their own stretchable shorts and spikes which they wore during the completion. Starting command was identical to that what is used in a competition setting. The athletes were given a test run to get used to the setting. The athletes one by one set themselves at the block for the sprint-start performance. For their first run the rear block obliquity was "set" at 400 and was then increased to 500 and 600 block angles, while the front block angle was kept constant at 400 block angle. Each sprinter ran four to six maximal-efforts 20m runs with enough time in between the runs so that the sprinters would get enough time for recovery. To serve this purpose the sprint-start runs were randomized between the sprinters. Data Analysis: Data analysis was done in two motion analysis software's including Silicon Coach pro-7 and Quintic Coaching.

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RESULTS

Figure 1: Various events in a sprint start performance

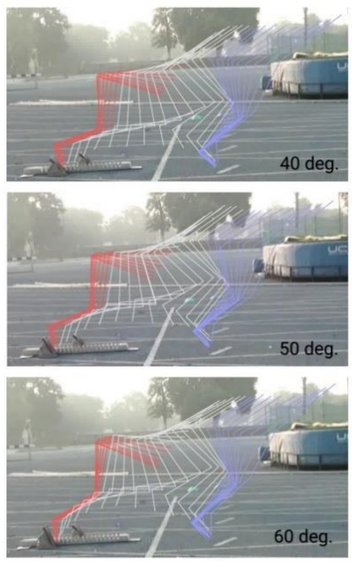

Figure 2: Subject specific stick figure analysis of sprint-start at various block pedal angles

Table 1.Lower Limb Kinematics at First Contact(FC) during a Sprint-Start Performance

Subjects	Hip joint angle(^{0}) (FC) at various block inclinations			Knee joint angle(^{0})(FC) at various block inclinations			Ankle joint(^{0})(FC) at various block inclinations		
	40^0	50^0	60^0	40^0	50^0	60^0	40^0	50^0	60^0
Sub. A	102	100	120	123^{L}	130^{L}	127^{L}	104	112	105
Sub. B	98	100	104	132^{H}	135	137^{H}	106^{H}	122^{H}	117^{H}
Sub. C	130^{H}	140^{H}	126^{H}	129	138^{H}	127	98^{L}	104^{L}	108
Sub. D	123	128	121	132	135	132	105	107	103^{L}
Sub. E	94^{L}	100^{L}	102^{L}	127	134	129	102	108	112

Note: FC means first contact; H stands for highest value and L stands for lowest value

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Table 2.Descriptive Statistics of Kinematics at First Contact(FC)

	Hip Joint Angle(FC)			Knee Joint Angle(FC)			Ankle Joint Angle(FC)		
	40^0	50^0	60^0	40^0	50^0	60^0	40^0	50^0	60^0
Mean	109.4	113.6	114.6	128.6	134.4	130.4	103	110.6	109
SD	16.06	19.1	10.85	3.78	2.88	4.22	3.16	6.99	5.61
COV	14.68	16.81	9.47	2.94	2.14	3.24	3.07	6.32	5.15

Note: values have been rounded to two digits after decimal; COV means coefficient of variance

Table 3.ANOVA Result-Details of Hip Joint Angle(FC)

Source	SS	df	MS	
Between-treatments	76.13	2	38.0667	F = 0.15424
Within-treatments	2961.6	12	246.8	
Total	3037.733	14		

The table-3 shows a non-significant result for the variable namely Hip Joint(FC), F(2,12)=0.154, p>.05.

Table 4.ANOVA Result-Details of Knee Joint Angle(FC)

Source	SS	df	MS	
Between-treatments	88.13	2	44.0667	F = 3.27228
Within-treatments	161.6	12	13.4667	
Total	249.7333	14		

The table-4 shows a non-significant result for the variable namely Knee Joint Angle (FC), F(2,12)=3.2722, p>.05.

Table 5.ANOVA Result-Details of Ankle Joint Angle(FC)

Source	SS	df	MS	
Between-treatments	160.53	2	80.27	F = 2.66667
Within-treatments	361.2	12	30.1	
Total	521.73	14		

The table-5 shows a non-significant result for the variable namely Ankle Joint Angle (FC), F (2,12) =0.154, p>.05.

DISCUSSION

The objective of the study was to provide an insight regarding the effect of block angles variation on the kinematics of the first stance. This in return would help in determining the right block configuration for elite athletes. With alteration in the block-pedal angles athletes must adjust themselves at varied lower limb configuration, so we hypothesized that the block inclination angles will have a carryover effect until the first contact. However, ANOVA revealed no significant difference in the kinematics of the first contact. Knee joint kinematics came the closest to showing a significant difference (f-value is 3.272: p-value is .0734). we accept there was an increased possibility of type II error because of a small sample size.

We also conclude that since our athletes were highly skilled (10.704±0.255 seconds; 100m personal best), so they might have increased efficiently to resist the alterations caused by various block angles. This could indicate a higher level of proprioception in comparison to sub-athletes since the alteration in block-pedal angles prompted no significant variation in the kinematics of lower limbs at first contact. Research suggests that proprioceptive acuity underpins the performance success achieved by sports elites (Han et al.,2015), this could be the reason, since our athletes had decent success at national level events.

For future studies we suggest that sample consisting of trained and untrained athletes be studied to confirm the true effect of the block angle variations as the trained athletes bring a learning effect into the experiment. In our other observation, a stick figure analysis revealed a persistent increase in ground clearance at various block angles (figure 2). Ground clearance could be one of the factors that contributes to braking force at first touchdown as it was sought in a recent review (Bezodis et al.,2015). A lesser ground clearance at first contact might reduce the ankle dorsiflexion, which has been found to increase first stance power in a computer simulation study (Bezodis et al., 2015). This draws ample room for more experimental studies on sprint start performance.

CONCLUSION

The study showed that the alteration in the block angle has no effect on the kinematics of the first step during a sprint start performance of highly trained sprinters.

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